Photon-fusion reactions from chiral dynamics with vector fields

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Photon-fusion reactions $\gamma\gamma \to PP$ (with $PP = \pi^0\pi^0$, π^-, $K^0\bar{K}^0$, K^+K^-, $\eta\eta$ and $\pi^0\eta$) play an important role in our understanding of non-perturbative QCD. As a systematic approach chiral perturbation theory (χPT) is applied to describe these reactions at low energies [1]. An extension of χPT to the resonance region can be achieved by recently proposed novel scheme [2], which implements constraints from micro-causality and coupled-channel unitarity.

The cross sections of fusion processes are very sensitive to hadronic final-state interactions. Therefore, a crucial input is a proper description of the Goldstone boson scattering. This study has been performed in [3] within the novel unitarization scheme. The scalar resonances $f_0(980)$ and (980) are dynamically generated from coupled-channel $PP \leftrightarrow PP$ interactions. An important ingredient of these calculations is the chiral Lagrangian supplemented with light vector-meson degrees of freedom. The latter plays a crucial role in the hadrogenesis conjecture [4].

In the case of photo-fusion reactions, the chiral Lagrangian has five unknown parameters [5]. They parameterize the strength of interaction terms involving two vector meson fields. These parameters are fitted to $\gamma\gamma \to \pi^0\pi^0$, $\pi^-, \pi^0\eta$ data and to the decay $\eta \to \pi^0\gamma\gamma$, which is linked to $\gamma\gamma \to \pi^0\eta$ by crossing symmetry. For the decay amplitude we use the tree-level result, while for the reaction amplitudes we use the full rescattering formalism outlined in [2]. The results are depicted in Figs. 1 and 2.

The photon-fusion cross sections for the two-pion final states are in good agreement with the existing experimental data from threshold up to about 0.9 GeV. The $a_0(980)$ meson in the $\pi^0\eta$ channel is dynamically generated and an accurate reproduction of the $\gamma\gamma \to \pi^0\eta$ data is achieved up to 1.2 GeV. Based on our parameter sets we predict the $\gamma\gamma \to K^0\bar{K}^0$, K^+K^-, $\eta\,\eta$ cross sections (see Fig. 2).

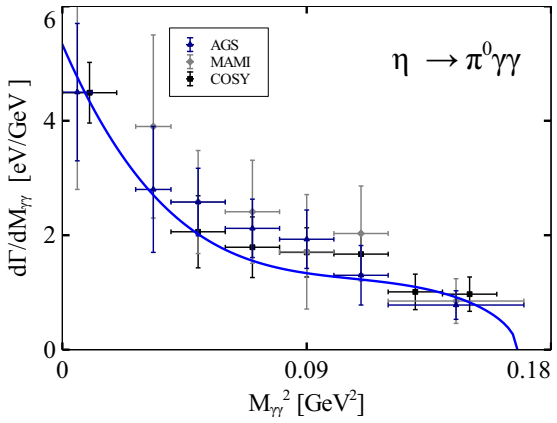

Figure 1: The single-differential invariant-mass distribution of the decay $\eta \to \pi^0\gamma\gamma$.

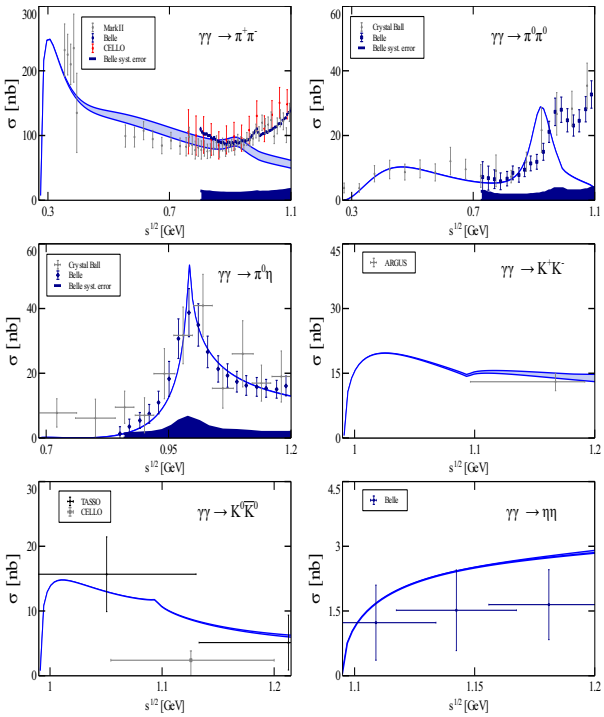

Figure 2: Total cross sections for the reactions $\gamma\gamma \to \pi^+\pi^-$, $\pi^0\pi^0$, $\pi^0\eta$, K^+K^-, $K^0\bar{K}^0$ and $\eta\eta$.

References

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